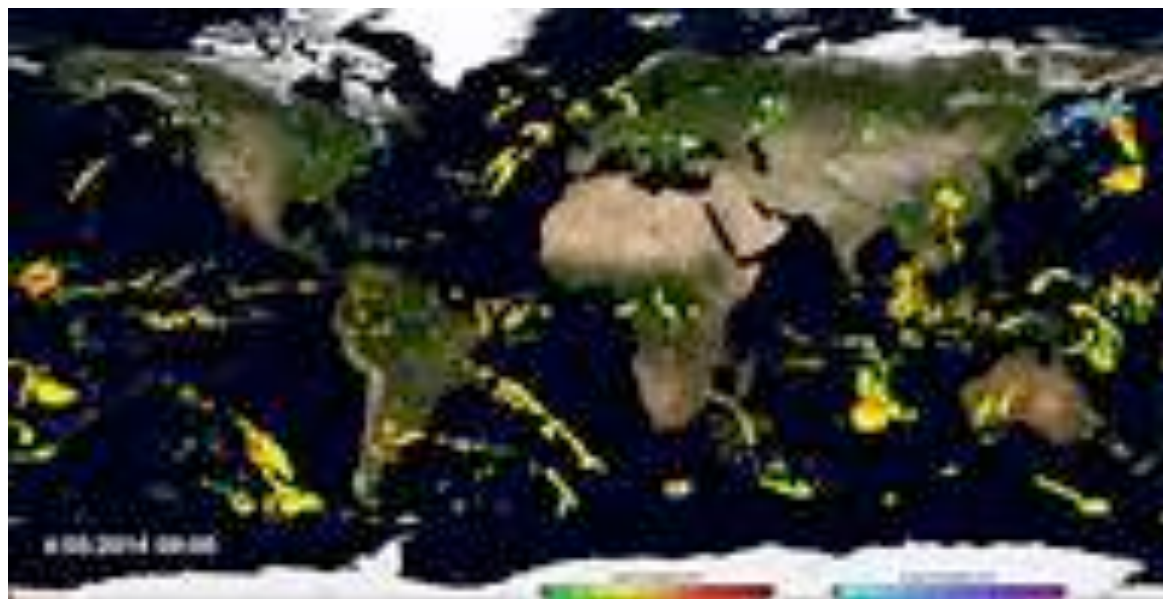




## Overview of NASA Hydrological Data Precipitation, Snow Cover



# Objective

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To provide an overview of precipitation products (rain and snow) from NASA satellites and models. Precipitation is major component of freshwater, responsible for extreme weather and flooding and associated with regional climate variability

# Outline

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- Precipitation data from NASA Satellites and Models
- Rainfall Data and Access

*The Tropical Rainfall Measurement Mission (TRMM)*  
*The Global Precipitation Measurement (GPM) Mission*  
*TRMM Applications*

- Snow Data and Access

*The Aqua/Terra Moderate Resolution Imaging  
Spectroradiometer (MODIS)*

# **Precipitation data from NASA Satellites and Models**



# NASA Remote Sensing Data for Rain and Snow

Satellite	Sensors	Quantities
TRMM	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS)	Rain Rate, Vertical Rain Rate Profile, Accumulated Rain
GPM	Dual Frequency Precipitation Radar (DPR) GPM Microwave Imager (GMI)	Rain Rate, Vertical Rain Rate Profile, Accumulated Rain
Terra and Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS)	Snow Cover, Vegetation Index, Leaf Area Index, Land Cover

Rain Rate has unit of mm/hour

Accumulated Rain has unit of mm (over a day or a month)

Snow Cover is the fractional area covered by snow

# NASA Models for Precipitation

	Models	Quantities
<p>These models assimilate satellite observations and are useful for weather, climate, and hydrology research</p> <p>This training will focus on higher spatial resolution satellite observations for rain and snow data</p>	MERRA	3-dimensional Winds, Temperature, Humidity, Clouds, <b>Rain Rate, Snow Mass, Snow Cover, Snow Depth, Surface Snowfall Rate</b> , Evapotranspiration
	GLDAS	Evapotranspiration, Multi-layer Soil Moisture, <b>Rainfall, Snowfall Rate, Snow Melt, Snow-Water Equivalent</b> , Surface and Sub-surface Runoff

Snow Rate has unit of mm/hour

Snow Water Equivalent has units of kg/m<sup>2</sup> or m

# Overview of Tropical Rainfall Measurement Mission (TRMM) Data and Access

**Important Note:**

TRMM mission was terminated in April 2015 but near-real time TRMM-calibrated rainfall from other satellites are available until GPM data become available in near-real time

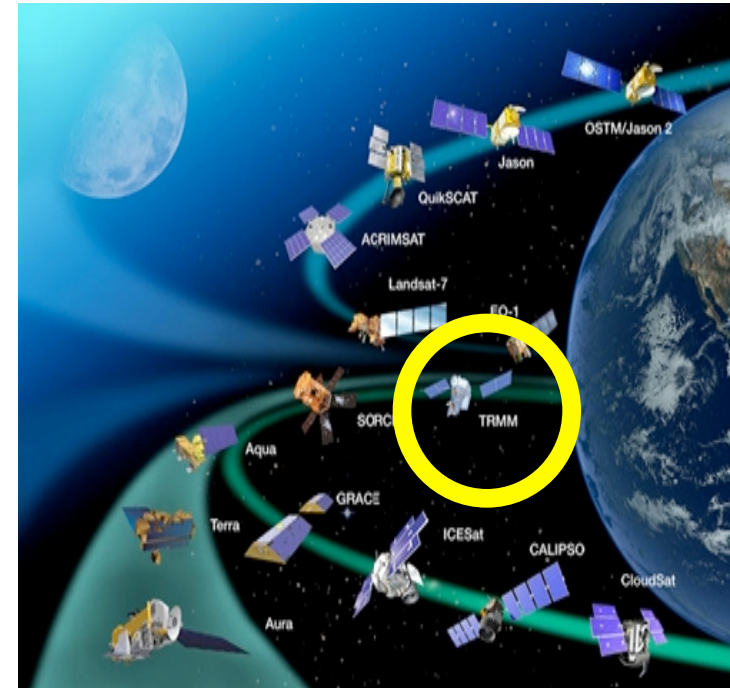
TRMM data from 1997-2014 are widely used for weather, climate, and hydrology applications

# Review of TRMM

## Tropical Rainfall Measuring Mission

<http://trmm.gsfc.nasa.gov>

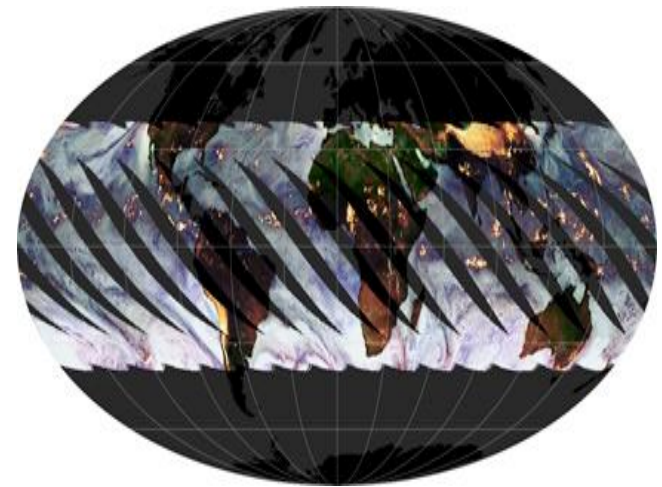
- ❑ The first satellite mission dedicated to measuring tropical and subtropical rainfall - Launched on 27 November 1997
- ❑ First satellite to carry a microwave Precipitation Radar
- ❑ Predecessor to Global Precipitation Measurement (GPM)



# Review of TRMM

<http://trmm.gsfc.nasa.gov>

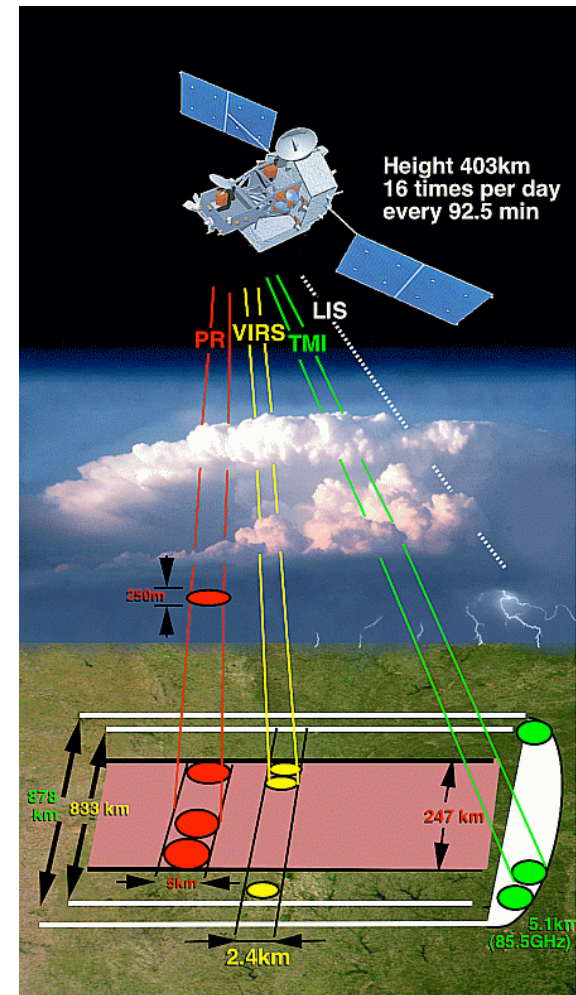
- ❑ **A non-polar, low inclination orbit**  
Revisit time ~11-12 hours, but time of the observation changes daily
- ❑ There are 16 TRMM orbits a day **covering global tropics between 35° S to 35°N latitudes**
- ❑ Altitude - of approximately 350 Km, raised to 403 Km after 23 August 2001



# TRMM

<http://trmm.gsfc.nasa.gov>

- ❑ Multiple sensors
- ❑ One active and two passive rain sensors  
*Precipitation Radar (PR)*  
*TRMM Microwave Imager (TMI)*  
*Visible and Infrared Scanner (VIRS)*
- ❑ Multiple rain products available from individual sensors, at varying spatial resolutions



# TRMM Multi-satellite Precipitation Analysis (TMPA)

## (Widely used in Environmental Applications )

Combination of TRMM - TMI, PR, VIRS with passive microwave, infrared and visible measurements available from national and international satellites provides rainfall data with --

Temporal Resolution :	3-hourly
Spatial Resolution:	0.25°x0.25°
Spatial Coverage:	Global 50°S to 50°N


Available in Near-real time data and also gauge-calibrated research quality version with ~ 3-month latency

**This training will focus on TMPA because it is available in near-real time and also for 15+ years – useful for flooding and climate applications**

# Summary of TRMM Level-2 Precipitation Products

\*Surface Rainfall Rate in mm/hour

TRMM data are available from December 1997 to present

Sensor/Product Name	Spatial Resolution and Coverage	Temporal Resolution	Data Format
TMI/2A12	5 km x 5 km Orbital and 16 orbits per day (38°S-38°N)	3-hour, 2-day  15 days	HDF4 and OPenDAP
PR/2A25	5 km x 5 km Orbital and 16 orbits per day (38°S-38°N)	3-hour, 2-day  5 days	
Combined TMI and PR /2B31	5 km x 5 km Orbital and (38°S-38°N)	3-hour, 2-day  5 days	


\*In addition to surface rainfall rate in mm//hour, vertical precipitation profiles and latent heating are available in these data products



# Summary of TRMM Level-3 Precipitation Products

\*Surface Rainfall Rate in mm/hour

**TRMM data are available from January 1998 to present**

Sensor/Product Name	Spatial Resolution and Coverage	Temporal Resolution	Data Format
TMPA/3B42 RT	0.25°x0.25° (50°S-50°N)	3-hourly (Near Real Time) daily, 10-day and 30-day Averages	HDF4, NetCDF, OPenDAP, ASCII GIF, PNG Images KML for Google Earth
TMPA/3B42 (Gauge Adjusted Research Version)	0.25°x0.25° (50°S-50°N)	3-hourly, daily	
TMPA/3B43	0.25°x0.25° (50°S-50°N)	Monthly	

\*In addition to surface rainfall rate in mm//hour, vertical precipitation profiles and latent heating are available in these data products

# TRMM TMPA Near-Real Time Images

<http://pmm.nasa.gov/TRMM/realtime-3hr-7day-rainfall>

3-hourly and  
7-day  
accumulated rain

Regional Rainfall  
Animation

Rainfall in  
Googleearth

The screenshot displays the TRMM (Tropical Rainfall Measuring Mission) website. On the left is a navigation menu with links like 'Mission Overview', 'Extreme Weather', 'Science Team', 'Instruments', and 'Products and Applications'. The main header includes the NASA logo, 'GODDARD SPACE FLIGHT CENTER', and a link to the 'NASA Homepage'. Below this is the 'TRMM Tropical Rainfall Measuring Mission' title and a 'HOME' button. A navigation bar contains links for 'ABOUT TRMM', 'NEWS', 'PUBLICATIONS', 'SEARCH', 'CONTACTS', 'DATA', and 'IMAGE POLICY'. The central section is titled 'Realtime 3 Hourly and 7 Day Rainfall Data' and contains introductory text. Below this is a map titled 'REGIONAL TRMM Based Rainfall' showing four regions: Africa, Asia, Pacific, and Americas, each with a corresponding colored button. At the bottom, there are buttons for 'Global Animations' and 'Extreme Events'. A footer section contains links for 'Point and Click' detailed rainfall data and 'Rainfall Images in Google Earth'.

**TRMM**  
Mission Overview  
Extreme Weather  
Science Team  
Instruments  
Products and Applications  
Latest Rainfall Data  
Global Flood and Land  
Monitoring  
Hurricanes and Typh  
Rain Averages and  
Anomalies  
TRMM Based Climate  
Quicklooks at TRMM  
TRMM Ground Validat

**Realtime 3 Hourly and 7 Day Rainfall Data**  
This page displays the latest global rainfall data collected by the TRMM satellite.  
For more information, view this video explaining TRMM's 3 hour rainfall measurements.

NASA GODDARD SPACE FLIGHT CENTER + NASA Homepage  
**TRMM** Tropical Rainfall Measuring Mission  
HOME  
ABOUT TRMM NEWS PUBLICATIONS SEARCH CONTACTS DATA IMAGE POLICY

**REGIONAL TRMM Based Rainfall**

30N  
EQ  
30S  
0 90E 180 90W  
Africa Asia Pacific Americas  
Global Animations Extreme Events

• "Point and Click" detailed rainfall data for specific coordinates: 24 Hour | 72 Hour | 168 Hour  
• Rainfall Images in Google Earth

# TRMM TMPA Access through Giovanni-4

<http://giovanni.gsfc.nasa.gov/giovanni/>

**EARTHDATA** Data Discovery ▾ DAACs ▾ Community ▾ Science Disciplines ▾

**GIOVANNI** The Bridge Between Data and Science v 4.13 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

**GOCART data no longer available...** [1 of 1 messages] [Read More](#)

**Select Plot**

☒ **Maps: Time Averaged Map** ▾ ☐ Comparisons: *Select...* ▾ ☐ Time Series: *Select...* ▾ ☐ Vertical: *Select...* ▾ ☐ Miscellaneous: *Select...* ▾

**Select Date Range (UTC)**

YYYY-MM-DD HH:mm  
- - 00:00 to - - 23:59  
Valid Range: 1979-01-01 to 2015-04-14

**Select Region (Bounding Box or Shapefile)**

Format: West, South, East, North  
-180, -90, 180, 90 [Show Map](#) [Show Shapes](#)

Please specify a start date.

**Select Variables**

▼ **Disciplines**

- ☐ Hydrology (4)
- ☐ Water and Energy Cycle (3)

▼ **Measurements**

- ☐ Precipitation (4)

► **Platform / Instrument**

► **Spatial Resolutions**

► **Temporal Resolutions**

► **Portal**

Number of matching Variables: 4 of 331

Keyword :  [Search](#) [Clear](#)

	Variable Name	Source	Temp. Res.	Spat. Res.	Begin Date	End Date	Vert. Slice
<input type="checkbox"/>	<a href="#">Precipitation Rate (TRMM 3B43 v7)</a>	TRMM	Monthly	0.25 °	1998-01-01	2014-10-31	-
<input type="checkbox"/>	<a href="#">Precipitation Rate (TRMM 3B43 v6)</a>	TRMM	Monthly	0.25 °	1998-01-01	2011-06-30	-
<input type="checkbox"/>	<a href="#">Precipitation Rate (TRMM 3B42_daily v6)</a>	TRMM	Daily	0.25 °	1997-12-31	2011-06-30	-
<input type="checkbox"/>	<a href="#">Precipitation Rate (TRMM 3B42_daily v7)</a>	TRMM	Daily	0.25 °	1997-12-31	2014-10-31	-

Total Variable(s) included in Plot: 0

[Help](#) [Reset](#) [Feedback](#) [Plot Data](#)

Daily and Monthly 0.25 degree TMPA (Product names: 3B42 and 3B43) available in NetCDF format, PNG or GeoTIFF Images

# TRMM TMPA Access through Mirador

<http://mirador.gsfc.nasa.gov/>

The screenshot shows the Mirador web interface with several annotations:

- Search Data using Keyword:** A red box highlights the "Keyword" search field with the text "IMERG".
- Temporal Selection:** A yellow box highlights the "To:" date field with the text "2014-07-16".
- Spatial Selection by latitude-longitude:** A red box highlights the "Location:" field with the text "TMAP".
- Spatial Selection from Map:** A red box highlights a map of North America with a red arrow pointing to it.
- Search:** A blue box highlights the "Search" button.

Additional features and text visible on the page include:

- Navigation links: Data Discovery, Data Centers, Community, Science Disciplines.
- Search bar: Search GES DISC, Search, Advanced Search.
- Section: Mirador Data Access Made Simple.
- Left sidebar: OVERVIEW, HELP CENTER, DATA HOLDINGS, VIEW CART, Additional Features (News, Restricted Data, Feedback, FAQ).
- Map area: Keyword: IMERG, To: 2014-07-16, Location: TMAP, Update Map, Search GES-DISC.
- Map labels: NORTH AMERICA, SOUTH AMERICA, EUROPE, ASIA, AFRICA, Atlantic Ocean, Pacific Ocean, Indian Ocean.
- Footer: Terms of Use, Report a map error, Advanced Search.

gazetteer locations such as Kansas or Ice Shelf; OR  
a bounding box: (minLat,minLon),(maxLat,maxLon)  
(LL),(UR) (Mirador will choose smallest area)  
OR 80N 20s 120east 20wes OR  
a partial Lat/Lon: of 22n is equivalent to (22,180),(-90,-180)

**Mirador is useful for searching data and downloading multiple data files in HDF or OpenDAP Formats**

# **Global Precipitation Measurement Mission (GPM)**

## **Designed to extend, enhance, and improve TRMM Precipitation Data**

### **TRMM Data Limitations:**

Does not provide measurements beyond 35°S-35°N

The TRMM sampling frequency is 15 hours to 4 days at any point which can introduce substantial uncertainties in rain estimates

TRMM provides rain measurements but not frozen precipitation, also cannot detect light rain (<0.5 mm/hr)

**GPM was designed to obtain measurements over tropics and higher latitudes, with improved capability to observe light rain and snow**

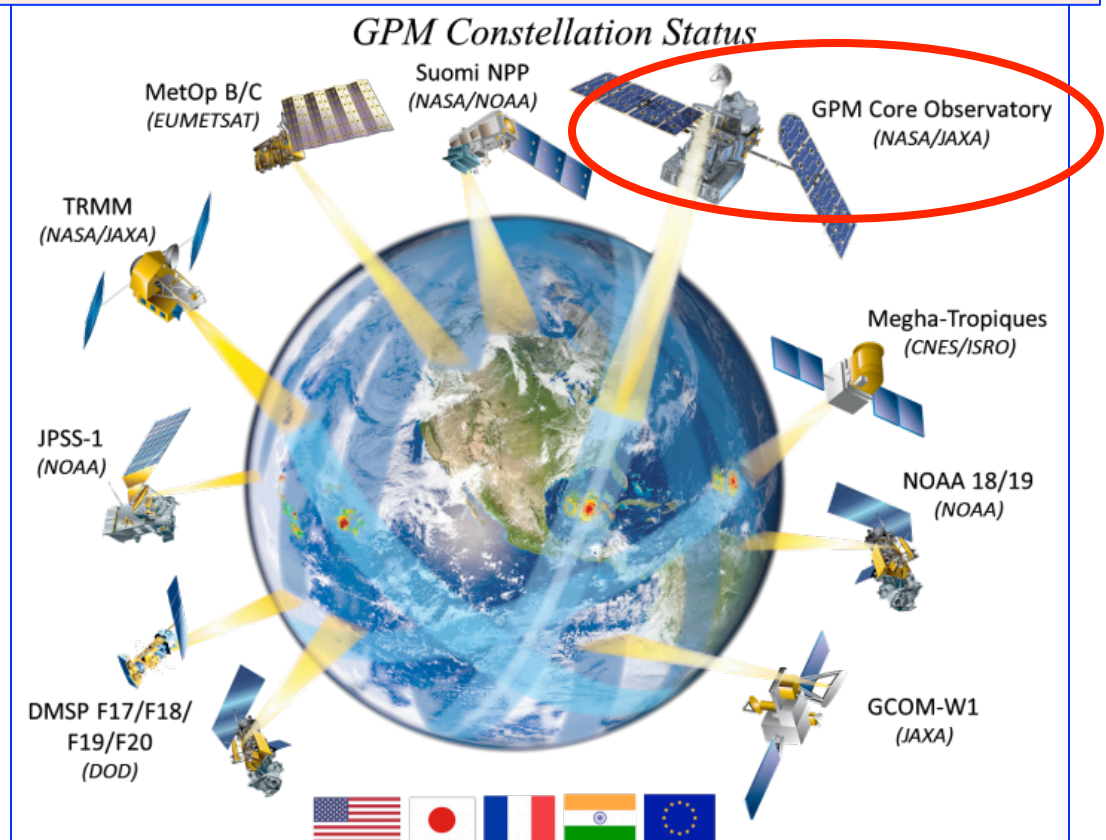
# **Overview of Global Precipitation Measurement (GPM) Data and Access**

# Global Precipitation Measurement (GPM)

<http://pmm.nasa.gov/GPM>

- An international network of satellites with a GPM Core satellite designed to provide global observations of rain and snow
- Initiated by NASA and the JAXA as a successor to TRMM

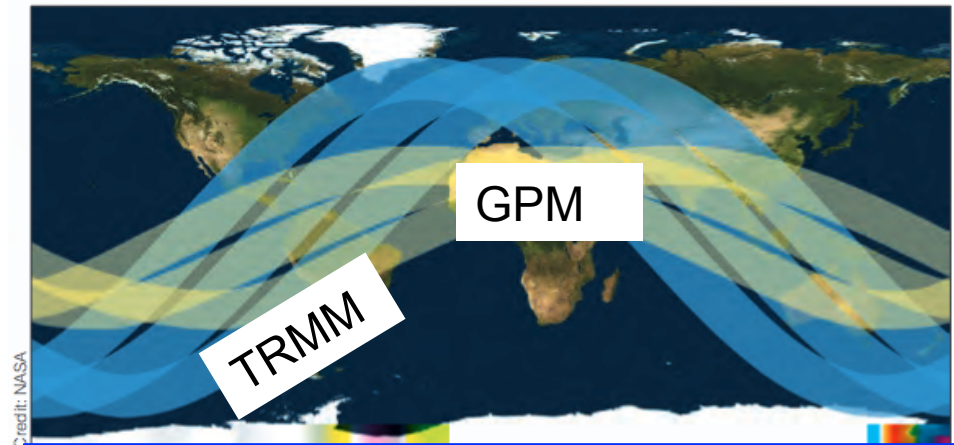
**GPM Core satellite was launched on  
February 27th, 2014**





# GPM Orbits and Spatial Coverage

- ❑ In non-polar, low inclination orbit with 16 orbits per day
- ❑ **GPM observes global regions between 65° S to 65°N latitudes**



the area covered by three TRMM orbits [yellow] versus orbits of the GPM Core Observatory [blue]

**GPM measurements span middle and high latitudes**



# GPM GMI and DPR Measurements

<http://pmm.nasa.gov/GPM>

## GMI

### Compared to TRMM TMI:

- ❑ Higher spatial resolutions
- ❑ Improved light rain and snow detection
- ❑ Reference for constellation radiometers calibration

## DPR

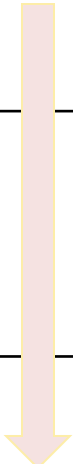
### Compared to TRMM PR:

- ❑ Higher sensitivity to light rain and snow
- ❑ Better accuracy of measurements
- ❑ Better identification of liquid, ice, mixed-phase precipitation particles
- ❑ Reference standard for inter-calibration of constellation precipitation measurements

# Summary of GPM Level-2 Precipitation Products

\*Surface Rainfall Rate in mm/hour

**GPM data are available from March 2014 to present**

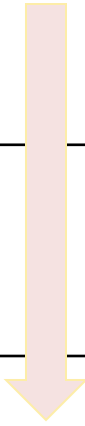
Sensor/Product Name	Spatial Resolution and Coverage	Temporal Resolution	Data Format
DPR Ku-only/ 2A-Ku DPR Ka-only/2A-Ka DPR KU & Ka/ 2A-DPR	5.2 km x125 m Single Orbit and 16 orbits per day (70°S-70°N)	20-120 minutes  24 hours	HDF5 and OPenDAP
GMI/2A-GPROF	4 km x 4 km Orbital and 16 orbits per day (70°S-70°N)	2 – 40 hours	
Combined GMI and DPR/2A-CMB	Orbital (70°S-70°N) 5 km x 5 km, Coincident Ku-Ka-GMI footprints	3 – 40 hours	

\*In addition to surface rainfall rate in mm//hour, vertical precipitation profiles and latent heating are available in these data products

# Summary of GPM Level-3 Precipitation Products

\*Surface Rainfall Rate in mm/hour

**GPM data are available from March 2014 to present**

Sensor/Product Name	Spatial Resolution and Coverage	Temporal Resolution	Data Format
IMERG	0.1°x0.1° (90°S-90°N)	30-minutes(Near Real Time) with 4-hour latency, 12-hour latency and 4-months latency	HDF4, NetCDF, OPenDAP, ASCII GIF, PNG Images KML for Google Earth
3-CMB Combined GMI + DPR rainfall Averages	0.1°x0.1° (70°S-70°N)	Monthly	
3-DPR rainfall Averages	0.25°x0.25° 5.0°x5.0° (67°S-67°N) for Daily (70°S-70°N) for Monthly	Daily and Monthly Daily and Monthly	
3-GPROF GMI rainfall Averages	0.25°x0.25° (90°S-90°N)	Daily and Monthly	

\*In addition to surface rainfall rate in mm//hour, vertical precipitation profiles and latent heating are available in these data products

**TMPA:** TRMM Multi-satellite Precipitation Analysis

**IMERG:** Integrated Multi-satellitE Retrievals for GPM

IMERG is Conceptually similar to TRMM TMPA, combines GPM GMI/DPR data with the GPM **constellation satellites** to yield improved spatial/temporal precipitation estimates:

	IMERG	TMPA
Temporal Resolution :	30-minutes	3 hours
Spatial Resolution:	0.1°x0.1°	0.25°x0.25°
Spatial Coverage:	Global 60°S to 60°N	Global 50°S to 50°N

**Constellation Satellites:**

GCOM-W, DMSP, Megha-Tropiques, MetOp-B, NOAA-N', NPP, NPOESS

## 2. IMERG Data Sets

Multiple runs accommodate different user requirements for latency and accuracy

- “Early” – 4 hours (flash flooding)
- “Late” – 12 hours (crop forecasting)
- “Final” – 3 months (research data)

Time intervals are half-hourly and monthly (Final only)

0.1° global CED grid

- PPS will provide sub-setting by parameter and location
- initial release covers 60°N-S

User-oriented services

- interactive analysis (GIOVANNI)
- alternate formats (KMZ, KML, TIFF WRF files, ...)
- area averages

	<b><i>Half-hourly data file (Early, Late, Final)</i></b>
1	<i>[multi-sat.] precipitationCal</i>
2	<i>[multi-sat.] precipitationUncal</i>
3	<i>[multi-sat. precip] randomError</i>
4	<i>[PMW] HQprecipitation</i>
5	<i>[PMW] HQprecipSource [identifier]</i>
6	<i>[PMW] HQobservationTime</i>
7	<i>IRprecipitation</i>
8	<i>IRkalmanFilterWeight</i>
9	<i>probabilityLiquidPrecipitation [phase]</i>
	<b><i>Monthly data file (Final)</i></b>
1	<i>[sat.-gauge] precipitation</i>
2	<i>[sat.-gauge precip] randomError</i>
3	<i>GaugeRelativeWeighting</i>
4	<i>probabilityLiquidPrecipitation [phase]</i>

# GPM Data Access Tools

Tools	Data Products and Formats	Analysis and/or Visualization	Data Download
Mirador <a href="http://mirador.gsfc.nasa.gov">http://mirador.gsfc.nasa.gov</a>	<b>L1B, L2, and L3 GMI-GPROF</b> <b>IMERG Half-hourly, Monthly</b> Orbital and Gridded Daily, Monthly HDF5, OPenDAP (can be converted to ASCII, Binary, NetCDF)	N/A	Batch Download
Giovanni <a href="http://giovanni.gsfc.nasa.gov/giovanni/">http://giovanni.gsfc.nasa.gov/giovanni/</a>	<b>IMERG Half-hourly, Monthly</b> NetCDF, GeoTIFF, PNG	<b>Visualization:</b> Map, Time Series, Scatter Plot, Histogram <b>Analysis:</b> Time-averaged Maps, Time Series, Scatter Plot, Map Correlations, Vertical Profiles, Time-averaged Differences	Download by Select and Click on Data Files
PPS/STORM <a href="https://storm.pps.eosdis.nasa.gov/storm">https://storm.pps.eosdis.nasa.gov/storm</a>	<b>L1B and 1C, L2, L3 GMI, DPR, GMI-DPR Combined Data</b> , Orbital and Gridded Daily, Monthly <b>IMERG Half-hourly, Monthly</b> HDF5, PNG	Map Visualization, Interactive Latitude/Longitude Point Data Value Display	FTP

Same as for TRMM

# Precipitation Processing System (PPS) Science Team On-Line Request Module (STORM)

<https://storm-pps.gsfc.nasa.gov/storm/>

The screenshot displays the STORM web interface. At the top is the NASA logo and the text "National Aeronautics and Space Administration". To the right are links for "+ PPS Contacts" and "+ Related Links". Below this is a banner with the word "STORM" in large, stylized letters, flanked by a satellite image and a precipitation radar plot. A navigation bar contains tabs: "- HOME", "+ DATA ACCESS", "+ TOOLS", "+ PRODUCT INFORMATION", and "+ REGISTRATION". The "HOME" tab is active, showing a "Home" button and a "Need Help?" section with links to the "STORM User Guide" and "helpdesk@pps-mail.nascom.nasa.gov". The main content area features "PPS Data Access" (for searching GPM and TRMM data) and "PPS Public Archive" (for accessing standard products via ftp). Below these are three boxes for "Precipitation Processing System (PPS)", "Global Precipitation Measurement Mission (GPM)", and "Tropical Rainfall Measuring Mission (TRMM)". A table lists available products with columns for Data Type, Algorithm, Satellite, Instrument, and Primary Content.

Data Type	Algorithm	Satellite	Instrument	Primary Content
1A	1A01	TRMM	VIRS	Counts
1A	1A11	TRMM	TMI	Counts
1A	1A21	TRMM	PR	Counts
1A	1A21	TRMM	PR	Counts
1A	1AGMI	GPM	GMI	Counts
1B	1B01	TRMM	VIRS	Radiance
1B	1B11	TRMM	TMI	Brightness Temperature
1B	1B21	TRMM	PR	Radar Power
1B	1B21	TRMM	PR	Radar Power
1B	1BGMI	GPM	GMI	Brightness Temperature
1B	1BKs	GPM	DPF KA	Radar Power

STORM is specifically designed for GPM and TRMM Precipitation data search, selection, download, and visualization

# Precipitation Processing System (PPS) Science Team On-Line Request Module (STORM)

<https://storm-pps.gsfc.nasa.gov/storm/>

Requires User  
Registration

The screenshot shows the STORM web interface. At the top is the NASA logo and the text "National Aeronautics and Space Administration". To the right are links for "+ PPS Contacts" and "+ Related Links". The main header features the "STORM" logo and a "Precipitation Radar" image. Below the header is a navigation bar with four tabs: "+ DATA ACCESS", "+ TOOLS", "+ PRODUCT INFORMATION", and "+ REGISTRATION".

On the left side, there is a "Need Help?" section with links to the "STORM User Guide" and "helpdesk@pps-mail.nascom.nasa.gov". Below this is a "News" section with two entries: "2/18/2015 - TRMM/PR data distribution during experimental operation period" and "1/15/2015 - PPS is releasing the first public version IMERG products".

The main content area is titled "PPS Data Access" and includes a description: "to search for GPM and TRMM data, order custom subsets and set up subscriptions." Below this is the "PPS Public Archive" section, described as "to access GPM and TRMM standard products via online ftp." It also states: "These are the products available to the public. To retrieve data go to PPS Data Access or PPS Public Archive."

A table of data products is displayed, with the header row highlighted by a red box. The table has five columns: "Data Type", "Algorithm", "Satellite", "Instrument", and "Primary Content".

Data Type	Algorithm	Satellite	Instrument	Primary Content
1A	1A01	TRMM	VIRS	Counts
1A	1A11	TRMM	TMI	Counts
1A	1A21	TRMM	PR	Counts
1A	1A21	TRMM	PR	Counts
1A	1AGMI	GPM	GMI	Counts
1B	1B01	TRMM	VIRS	Radiance
1B	1B11	TRMM	TMI	Brightness Temperature
1B	1B21	TRMM	PR	Radar Power
1B	1B21	TRMM	PR	Radar Power
1B	1BGMI	GPM	GMI	Brightness Temperature
1B	1BKs	GPM	PRR_KA	Radar Power

On the right side of the interface, there are three boxes: "PPS Precipitation Processing System (PPS)", "Global Precipitation Measurement Mission (GPM)", and "Tropical Rainfall Measuring Mission (TRMM)".


Data Product  
Search

STORM is specifically designed for GPM and TRMM Precipitation data search, selection, download, and visualization




# Precipitation Processing System (PPS) Science Team On-Line Request Module (STORM)

<https://storm-pps.gsfc.nasa.gov/storm/>



National Aeronautics  
and Space Administration

+ PPS Contacts  
+ Related Links




+ HOME- DATA ACCESS+ TOOLS+ PRODUCT INFORMATION+ REGISTRATION


**Data Access**  
+ BROWSE ARCHIVE  
- SEARCH ARCHIVE / ORDER  
+ SAT - SAT COINCIDENCE  
+ TRACK ORDER STATUS



**Need Help?**

- Click on ? for context specific help.
- [STORM User Guide](#)
- [helpdesk@pps-mail.nascom.nasa.gov](mailto:helpdesk@pps-mail.nascom.nasa.gov)

**Email**

 **Required**



**Enter email address to Register Or Request Registration**

**SECURITY**

NASA / PPS may provide links to Web pages that are not part of the NASA Web family or nasa.gov domain. These sites are managed by organizations, companies, or individuals and not under NASA control, and NASA is not responsible for the information or links you may find there. NASA provides links to these sites merely as a convenience. NASA is not responsible for the information collection practices of non-NASA sites. Once you link to another site, you are subject to the privacy policy of the new site, and you should read that site's policies on privacy and information collection.

# Precipitation Processing System (PPS) Science Team On-Line Request Module (STORM)

<https://storm-pps.gsfc.nasa.gov/storm/>

Product Type ?

 Required

## Product Selection

Left click on the header to sort rows. Right click to show/hide columns

Select	Data Type ?	Algorithm ?	Start Time ?	Frequency ?	Satellite or Ground Validation Site ?	Instrument ?	Primary Content ?	Spatial Extent ?
<input type="checkbox"/>	3B				GPM			
<input type="checkbox"/>	3B	3CMB ?	2014-03-01 00:00:00	MONTH	GPM	DPR, GMI	Precipitation	[70.0,-70.0,180.0,-180.0], [67.0,-67.0,180.0,-180.0]
<input type="checkbox"/>	3B	3CMB ?	2014-12-02 00:00:00	DAY	GPM	DPR, GMI	Precipitation	[70.0,-70.0,180.0,-180.0], [67.0,-67.0,180.0,-180.0]
<input type="checkbox"/>	3B	3IMERGHH ?	2014-03-12 00:00:00	30_MINUTE	GPM	DPR	Precipitation	[90.0,-90.0,180.0,-180.0]
<input type="checkbox"/>	3B	3IMERGM ?	2014-03-12 00:00:00	MONTH	GPM	DPR	Precipitation	[90.0,-90.0,180.0,-180.0]

Total Product Types selected: 0

Note: Some selected Product Types might not be visible if filters are used

Temporal Criteria

☒ Date Range ☐ Orbit Numbers

Valid range is between 20140312 and 20150310

YYYYMMDD [HH:MM]  
[ ] = optional fields

Start Date/Time 20150130 00:00

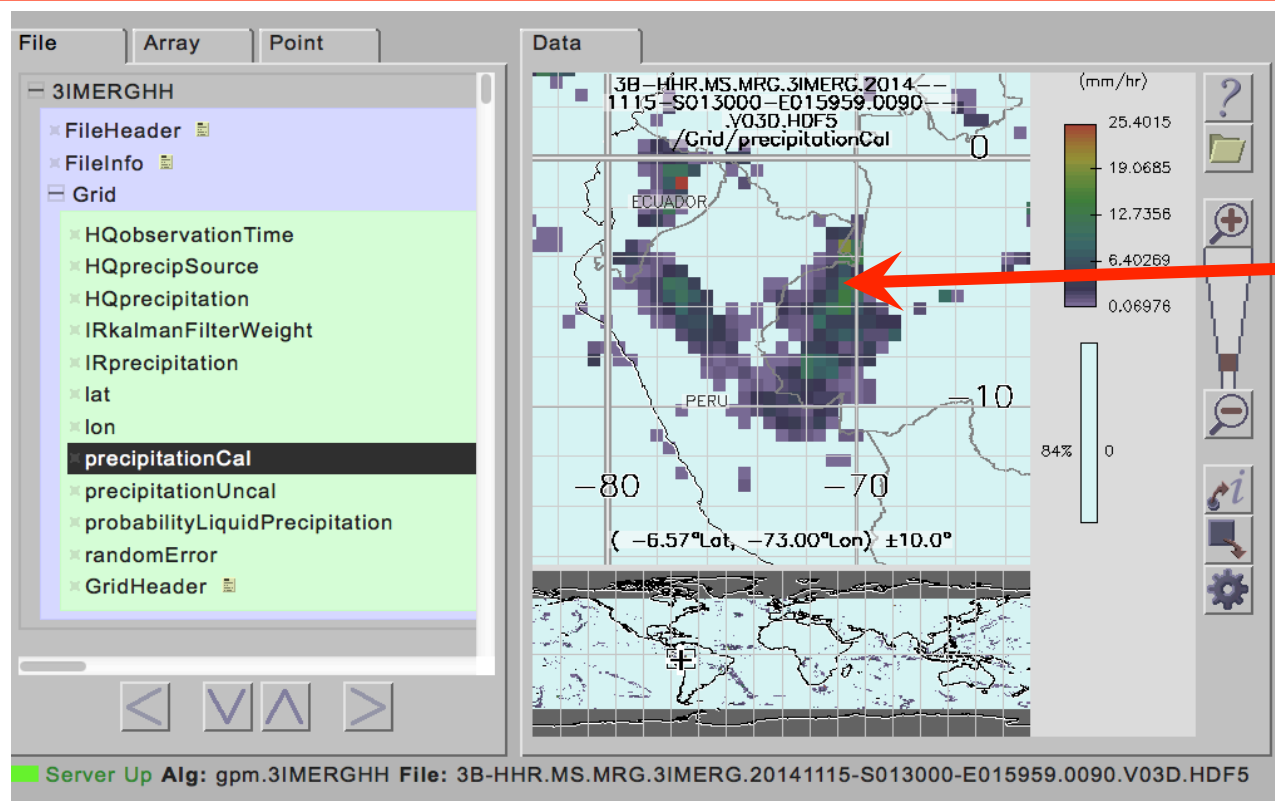
Stop Date/Time 20150130 23:59

## Temporal Selection

# Precipitation Processing System (PPS) Science Team On-Line Request Module (STORM)

<https://storm-pps.gsfc.nasa.gov/storm/>

Product Selection, Download, and Visualization by using  
Tool for High-resolution Observation Review (THOR)



Precipitation on  
November 15,  
2014

**TRMM data are used for a variety of applications, these applications will continue, using improved GPM data**

## **PRECIPITATION DATA APPLICATIONS**

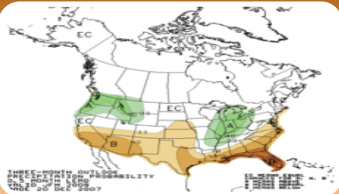
# Societal Benefit Areas of TRMM and GPM Precipitation



## Extreme Events and Disasters



## Water Resources and Agriculture



## Weather, Climate & Land Surface Modeling

- Numerical Weather Prediction
- Land System Modeling • Global Climate Modeling



## Public Health and Ecology

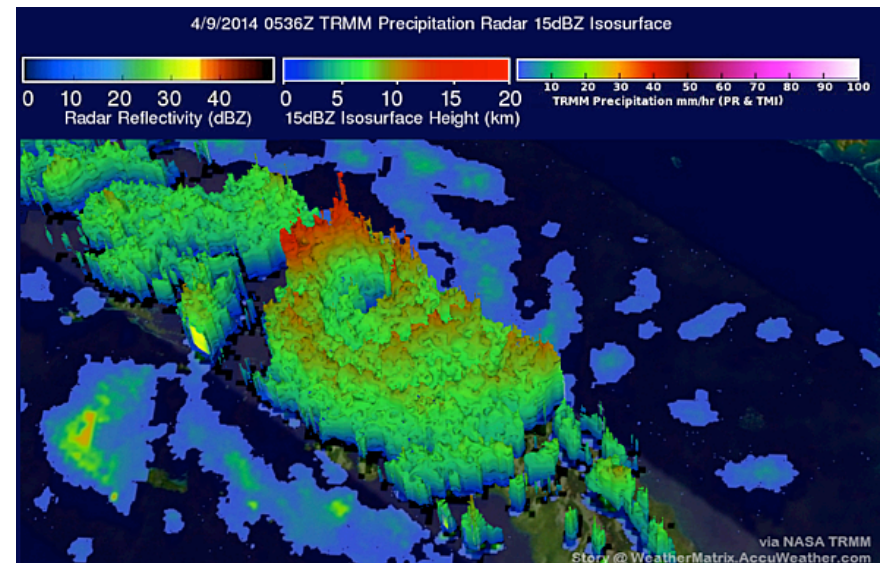
Courtesy: Dalia Kirschbaum, *GPM Applications Science Lead*

# TRMM Data Are Used in Weather Monitoring

Used by AccuWeather (<http://www.accuweather.com>) to monitor storms and heavy rainfall

Monster Australia Cyclone Ita, April 9 & 10, 2014

- GPM data will be used by tropical cyclone forecasting centers worldwide to detect the location and intensity of tropical cyclones.
- GPM's orbit (unlike TRMM's) will enable observation of tropical cyclones as they progress from tropical to mid-latitude systems



TRMM PR and TMI showing heavy rainfall within the storm

# TRMM Data Are Used to Provide Early Warning of Extreme Rainfall and Flooding For Developing Countries

GPM-IMERG will be used for extreme rainfall detection by ITHACA)

Used by Information Technology for Humanitarian Assistance, Cooperation, and Action (ITHACA) [www.ithacaweb.org](http://www.ithacaweb.org)

- ❑ Extreme Rainfall Detection System – Version 2 (**ERDS2**) uses near-real time **3-hourly TMPA**  
(<http://www.ithacaweb.org/projects/erds/>)
- ❑ **ERDS2** is a strategic tool, providing immediate information about potential flood events, used by the **UN World Food Programme (WFP)** Emergency Preparedness Unit

ITHACA provides trainings to government staff in developing countries on how to use ERDS2 and remote sensing data for flood hazard assessment

<http://www.ithacaweb.org/news/>



## ITHACA delivers technical training to Malawi Gov't staff

Fri 16 Jan 2015

Within the World Bank financed project [MASDAP](#), ITHACA held a technical training session on the use of satellite data for vulnerability assessment in Blantyre from December 15 to 19, 2014.

[Read more.](#)

## ITHACA hosts 3 Ethiopian interns for technical training on GIS and GPS systems

Mon 20 Oct 2014

On October 20 ITHACA started a 3-week specialization module on GIS and GPS systems for 3 Ethiopian trainees in the framework of the [WATSAM](#) project, coordinated by [Hydroaid](#) - Water for Development Management Institute.

[Read more.](#)

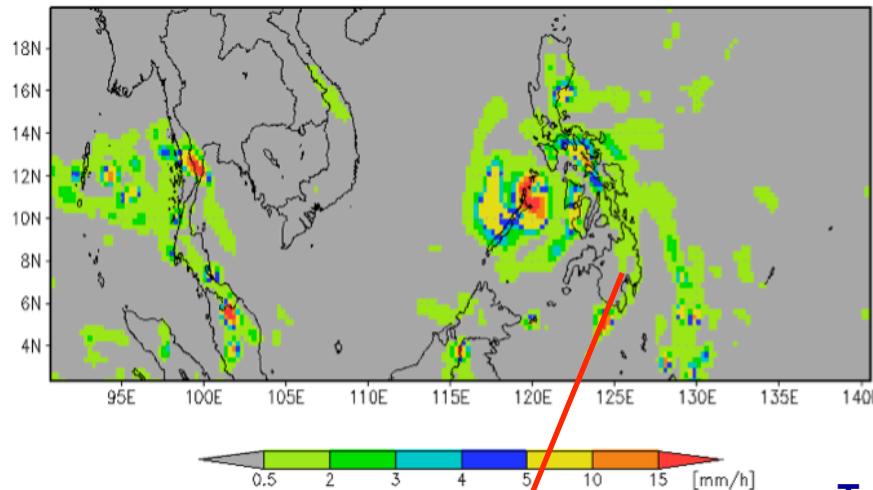
## Satellite-based Rapid Mapping training in Lilongwe (September 29 – October 1, 2014)

Wed 15 Oct 2014

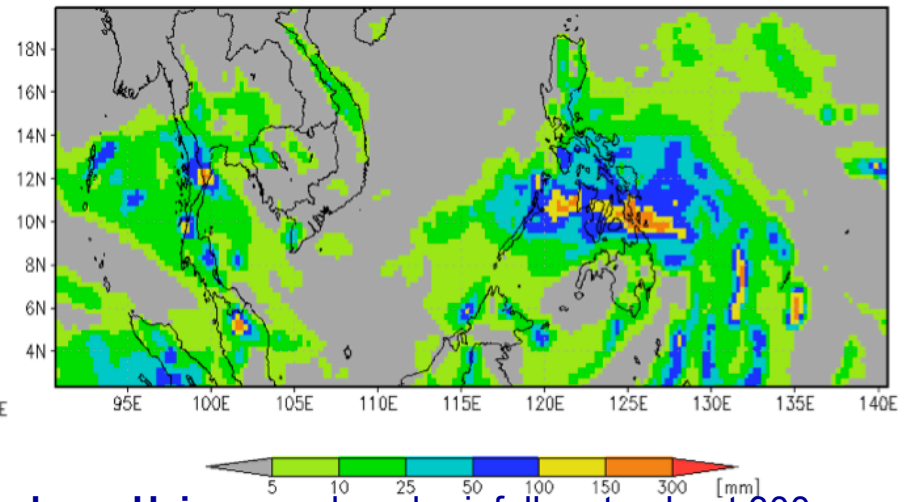


# TRMM Data Are Used for Flooding Estimates

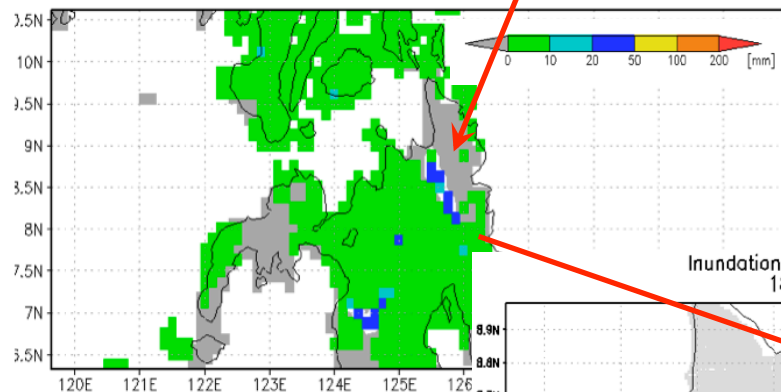
Rainfall (Instantaneous) [mm/h] 12Z08Nov2013



Rainfall (1-day accum.) [mm] 12Z08Nov2013



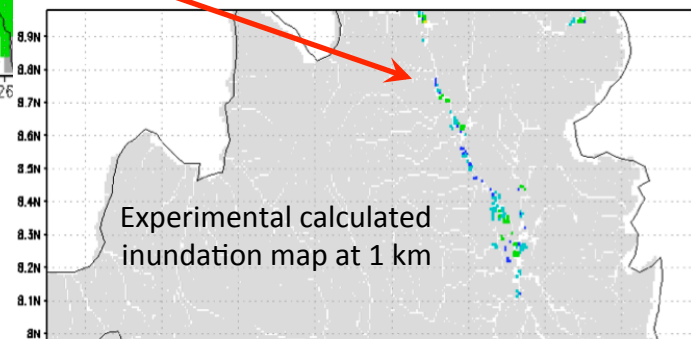
Flood Detection/Intensity (depth above threshold [mm])  
18Z07Nov2013



[flood.umd.edu](http://flood.umd.edu)

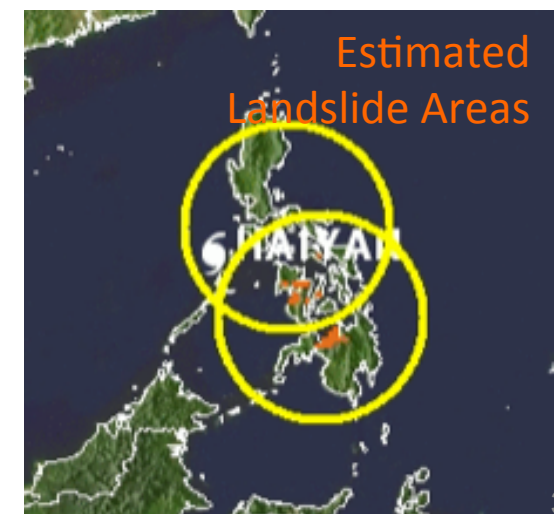
Adler/Wu  
U. of Maryland

Inundation map 1km res. [mm]  
18Z07Nov2013



**Typhoon Haiyan** produced rainfall up to about 300 mm.

Flooding estimated from Haiyan and previous rainfall along with landslides. **GPM will enable high resolution (compared to TRMM) flood detection and mapping.**



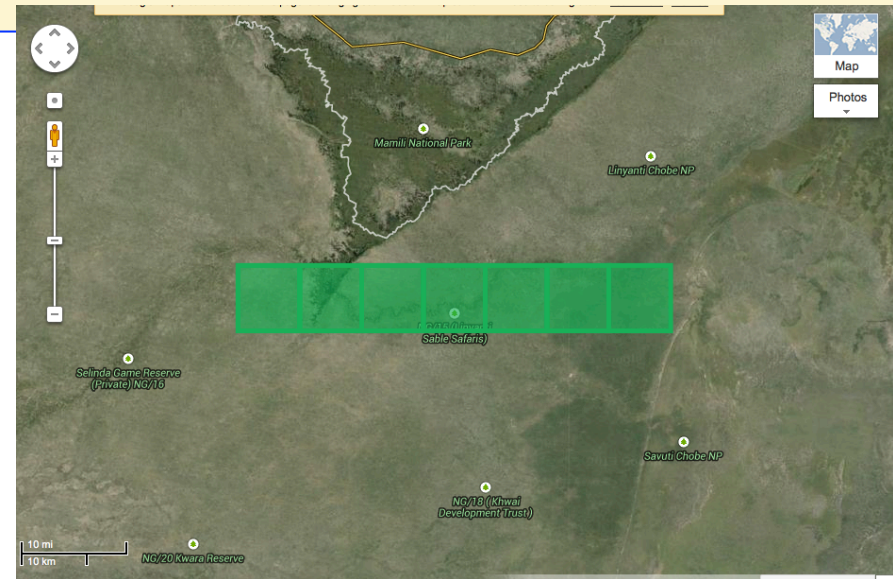
Courtesy: Dalia Kirschbaum, *GPM Applications Science Lead*



# TRMM Data Are Used by Global Disaster Alert and Coordination System (GDACS)

GDACS, managed by the United Nations and European Commission, provides disaster alerts and river watch that is used by many governments and about 14,000 disaster response and non-governmental organizations for their national disaster response plans. (<http://www.gdacs.org>)

One of the data sources used by GDACS is river run off derived from TRMM-TMI data by Dartmouth Flood Observatory  
(<http://www.dartmouth.edu>)

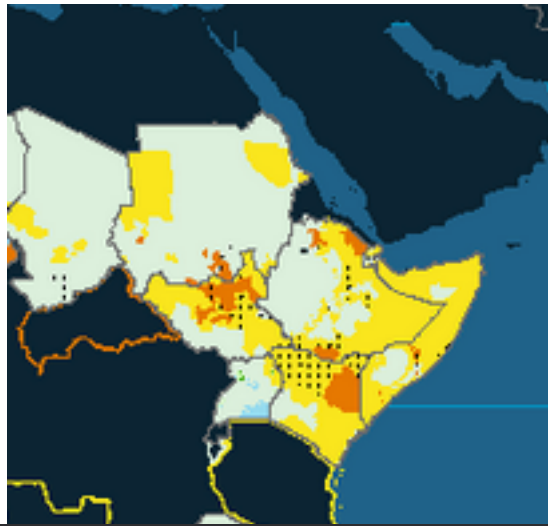


Flooding alert in Botswana  
on 15<sup>th</sup> December 2014

Higher resolution and extended spatial coverage by GPM-GMI will provide improved river-run off estimates

# TRMM Data Are Used in Agricultural Forecasting

January 2015 Report



**Famine Early Warning System (FEWS) relies on TRMM and other satellite estimates for anticipating poor growing seasons. GPM will improve these estimates.**

**FEWS NET Data Portal**

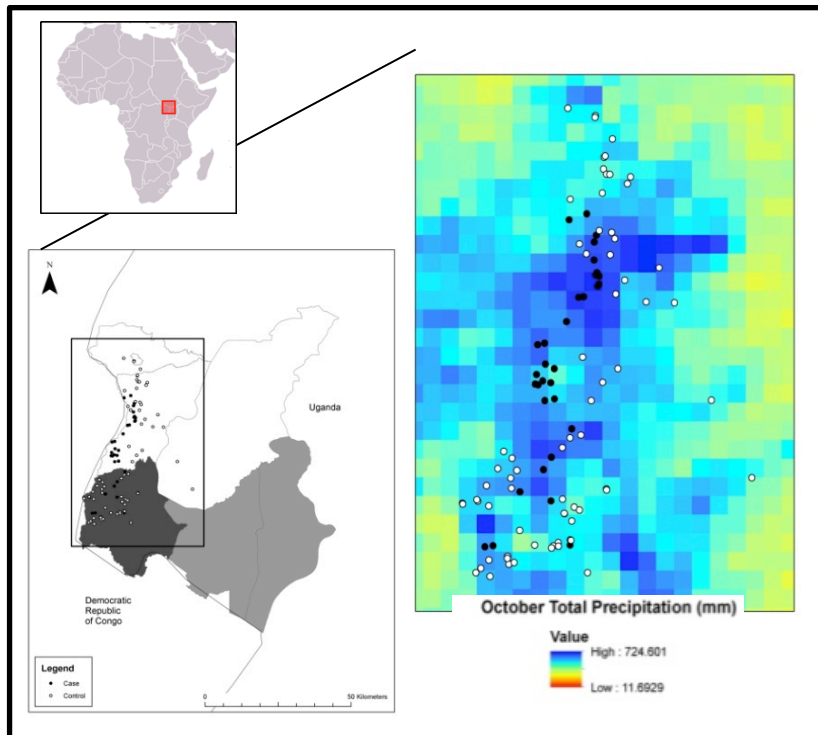
<http://earlywarning.usgs.gov/fews>

<http://www.fews.net>

# TRMM Data Are Used in Disease Tracking

TRMM data has been used to estimate and trace the source areas of vector and river-borne diseases around the world. **GPM will enable higher resolution evaluation of these disease source areas.**

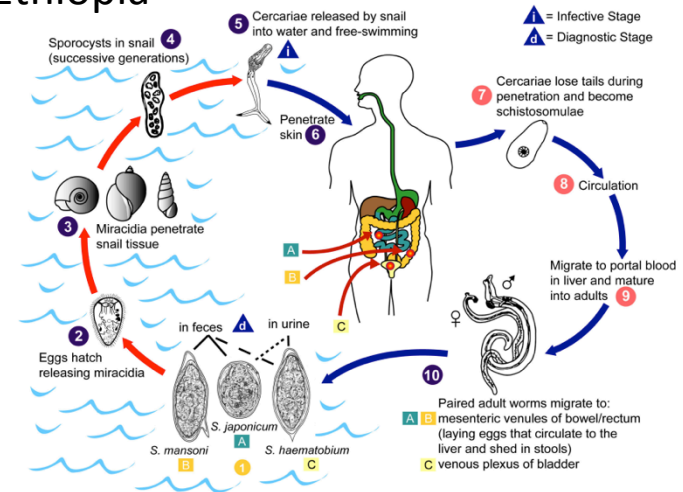
## Observed Plague Cases in Uganda



Cases are associated with wetter, cooler regions

*Monaghan et al. 2012; MacMillan et al., 2012*

## Schistosomiasis (snail-spread) in Ethiopia



Courtesy of Bitew and

Studies have found a relationship between TRMM rain and the onset of this disease in local populations due to contact with snails in irrigation channels

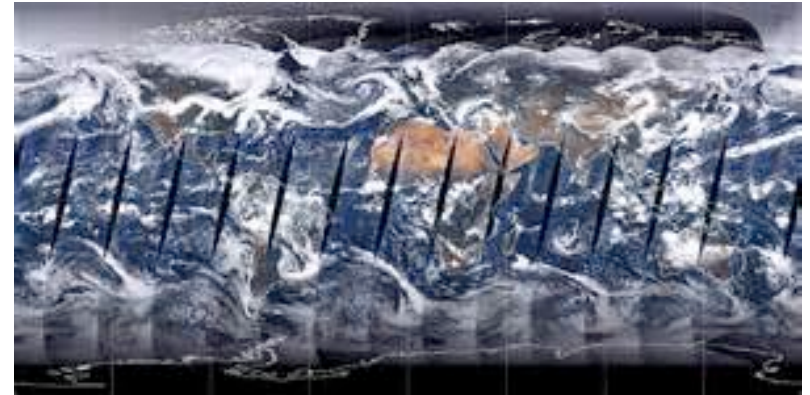
## **Snow Data and Access**

# Review of Terra and Aqua

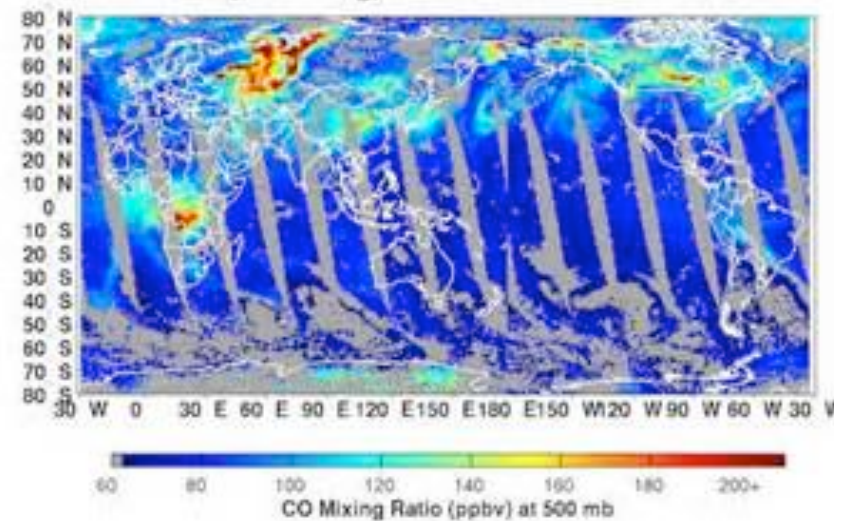
<http://trmm.gsfc.nasa.gov>

## Terra

- ❑ Polar, Sun-Synchronous Orbit, Global Coverage
- ❑ Twice-daily Observations 10:30 AM/PM Descending Orbits
- ❑ From 12/1999 – Present



Local noon (ascending) AIRS CO at 500 mb on 2010.08.01.



## Aqua

- ❑ Polar, Sun-Synchronous Orbit, Global Coverage
- ❑ Twice-daily Observations 1:30 AM/PM Descending Orbits
- ❑ From 5/2002 – Present



# Terra and Aqua MODerate Resolution ImagingSpectroradiometer (MODIS)

<http://modis.gsfc.nasa.gov/>

- A key instrument aboard Terra and Aqua providing 4-times per day observations (1:30 and 10:30 AM/PM) from the two satellites
- There are 36 spectral bands designed to observe atmosphere, land, and ocean
- Multiple data products and tools available



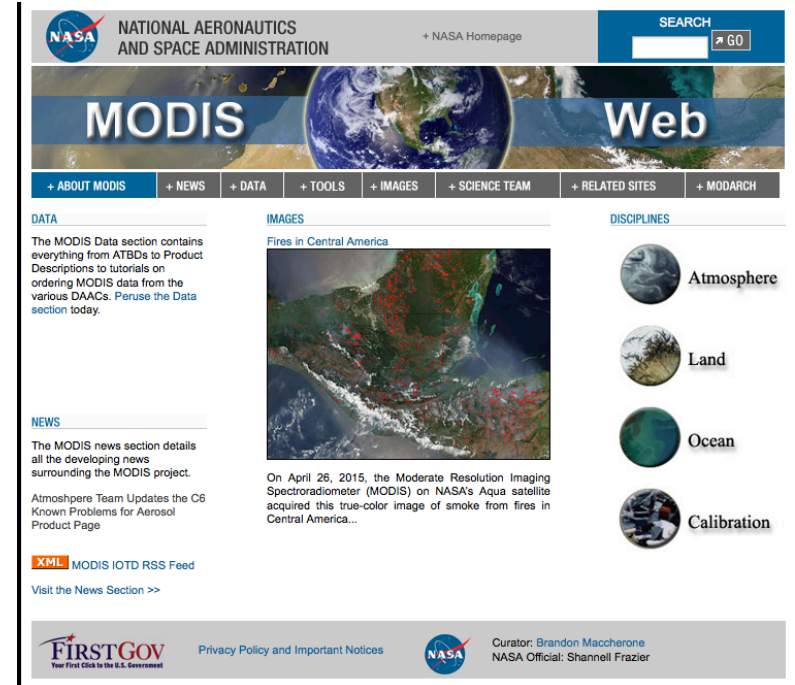
More information about obtaining MODIS data can be found from the information sites listed below. The URL's for these sources of data are as follows:

**MODIS Level 1 data, geolocation, cloud mask, and Atmosphere products:**  
<http://adsweb.nascom.nasa.gov/>

**MODIS land products:**  
<https://lpdaac.usgs.gov/>

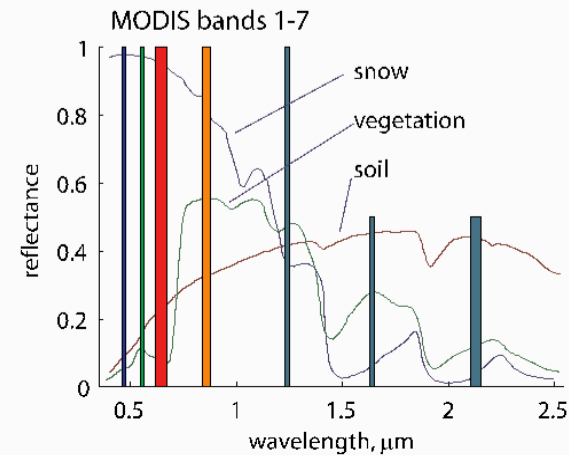
**MODIS cryosphere products:**  
<http://nsidc.org/daac/modis/index.html>

**MODIS ocean color and sea surface temperature products:**  
<http://oceancolor.gsfc.nasa.gov/>



# Terra and Aqua MODerate Resolution Imaging Spectroradiometer (MODIS)

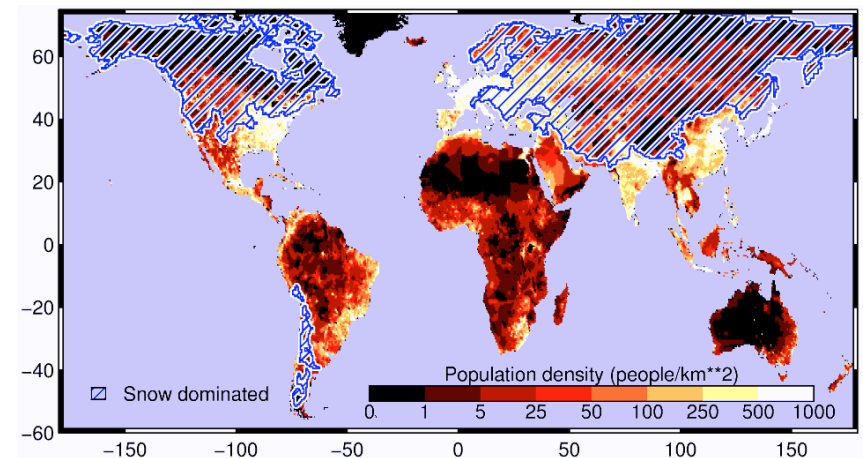
- 36 spectral bands ranging from 0.41 to 14.385 microns
- Many applications, including **clouds, snow/ice**, vegetation, aerosol
- Available in various resolution (depends on product)



# There are Two MODIS-based Snow Data Products

- Standard MODIS Product: Fractional Snow Cover
- MODSCAG (MODIS Snow Covered Area and Grain-size) Product : Fractional Snow Cover, Grain Size, Snow Water Equivalent

## Snow Dominated Regions





**Table 2. MODIS snow data products.**

**From Dorothy Hall NASA-GSFC**

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Long Name	Earth Science Data Type (ESDT)	Spatial Resolution
MODIS/Terra Snow Cover 5-Min L2 Swath 500m	MOD10_L2	500-m resolution, swath of MODIS data
MODIS/Terra Snow Cover Daily L3 Global 500m SIN Grid (includes daily snow albedo)	MOD10A1	500-m resolution, projected, gridded tile data
MODIS/Terra Snow Cover 8-Day L3 Global 500m SIN Grid	MOD10A2	500-m resolution, projected, gridded tile data
MODIS/Terra Snow Cover Daily L3 Global 0.05Deg CMG	MOD10C1	0.05° resolution, lat/lon climate modeling grid
MODIS/Terra Snow Cover 8-Day L3 Global 0.05Deg CMG	MOD10C2	0.05° resolution, lat/lon climate modeling grid
MODIS/Terra Snow Cover Daily L3 Global 0.25Deg CMG	Not yet a standard product	0.25° resolution, lat/lon climate modeling grid
MODIS/Terra Snow Cover Monthly L3 Global 0.05Deg CMG	MOD10CM	0.05° resolution, lat/lon climate modeling grid
MODIS/Aqua Snow Cover 5-Min L2 Swath 500m	MYD10_L2	500-m resolution, swath of MODIS data
MODIS/Aqua Snow Cover Daily L3 Global 500m SIN Grid (includes daily snow albedo)	MYD10A1	500-m resolution, projected, gridded tile data
MODIS/Aqua Snow Cover 8-Day L3 Global 500m SIN Grid	MYD10A2	500-m resolution, projected, gridded tile data
MODIS/Aqua Snow Cover Daily L3 Global 0.05Deg CMG	MYD10C1	0.05° resolution, lat/lon climate modeling grid
MODIS/Aqua Snow Cover 8-Day L3 Global 0.05Deg CMG	MYD10C2	0.05° resolution, lat/lon climate modeling grid
MODIS/Aqua Snow Cover Monthly L3 Global 0.05Deg CMG	MYD10CM	0.05° resolution, lat/lon climate modeling grid

# MODIS Standard Snow Product Data Access and Visualization

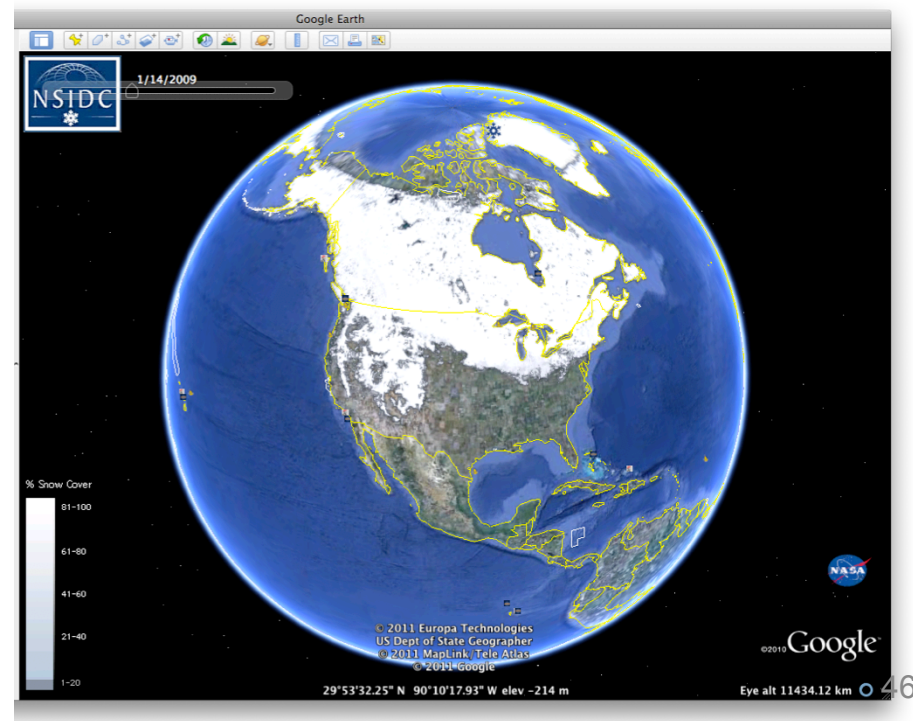
MODIS Snow Products are available from the National Snow and Ice Data Center <http://nsidc.org/>

MODIS monthly snow cover can be visualized on Google Earth maps from [http://nsidc.org/data/virtual\\_globes/index.html](http://nsidc.org/data/virtual_globes/index.html)

**Data Start Date: 2000-02-24**  
**Daily, 8-Day, Monthly**

**Coverage: Global**

**Multiple Spatial Resolutions**



# Selected Aqua-MODIS Snow Product from Reverb/ECHO

<http://reverb.echo.nasa.gov/reverb>

The screenshot displays the Reverb/ECHO web interface. The top header features the NASA logo, the text "National Aeronautics and Space Administration", and "EOSDIS NASA's Earth Observing System Data and Information System". The right side of the header says "Reverb | ECHO The Next Generation Earth Science Discovery Tool". Below the header, the "Spatial Search" section includes a "Bounding Box" input field with the example coordinates "-50.736, 163.477, -11.144, 105.680 (S,E,N,W)", "Reset", and "Clear" buttons. A map of the world is shown with a "Satellite" dropdown menu and a "Click and drag to set a bounding rectangle" instruction. The "Temporal Search" section has "START" and "END" date pickers with "YYYY-MM-DD HH:MM:SS" format and "Clear" buttons. A note states "\* all times must be specified in GMT". At the bottom of the temporal search section are "Date Range" and "Annual Repeating Dates" tabs.

## Step 2: Select Datasets

☐ MODIS/Aqua Snow Cover Monthly L3 Global 0.05Deg CMG V005  
Archive Center: NSIDC Short Name: MYD10CM Version: 5

Swath, Daily, and Monthly products are available



# Near-real Time Standard MODIS Products

<http://lance-modis.eosdis.nasa.gov/>

The screenshot shows the LANCE-MODIS website. At the top, the NASA logo and 'GODDARD SPACE FLIGHT CENTER' are on the left, and '+ Visit NASA.gov' is on the right. The main heading 'LANCE-MODIS' is centered. Below it is a navigation bar with three tabs: '- ABOUT' (highlighted in blue), '+ DATA PRODUCTS' (highlighted with a red box), and '+ USER SERVICES'. On the left side, there is a sidebar with '+Home' and 'About' links. The main content area under the 'DATA PRODUCTS' tab contains the following text:

LANCE-MODIS will operate on a 7x24 hour basis. LANCE-MODIS has two standalone systems that use different network routes. It is expected that this redundancy will reduce the system downtime to less than 1%.

Whereas the standard MODIS forward processing acquires 2-hour L0 files for Aqua and Terra from EDOS within 7-8 hours of real time, LANCE-MODIS acquires session-based L0 files from EDOS and the end of the session is available within 10-30 minutes after real time. LANCE-MODIS uses the Terra attitude and ephemeris data entrained in the L0 data. However, for Aqua the attitude and ephemeris data are acquired from the EDOS rate buffer. All of the MODIS Level 1 (L1), L2, and L3 products generated by LANCE-MODIS have been modified to add "NRT" metadata to the filenames to enable the products to be distinguished from the MODIS standard forward-processed products. LANCE-MODIS acquires all of the ancillary products from the data suppliers. The production rules for some of the science codes have been relaxed with respect to these ancillary data to allow the data products to be generated within 3 hours of real time.

Data products are archived in a rolling archive for 7+ days and are available for distribution by direct access to the [FTP sites](#).

LANCE-MODIS Details:

- [Hardware Configuration](#)
- [Data Flows for MODIS](#)
- [Distribution and Latency Metrics](#)

At the bottom, there is a footer with '+ Privacy Policy and Important Notices' on the left, the NASA logo in the center, and 'Webmaster: [Shriram Ilavajhala](#)  
NASA Official: [Ed Masuoka](#)' on the right.

# Near-real Time Standard MODIS Products

<http://lance-modis.eosdis.nasa.gov/>

Level-2 Swath data (500) m and 5 Km resolution Snow Cover available from Terra and Aqua MODIS

## Terra

			Fraction Browse					
L2 Snow Cover, 5-Min Swath 500m	MOD10_L2	0.26	L2 Snow Cover Browse	N/A	07	0:46	1:32 (8)	3:14
L2 Coarse Snow Cover, 5-Min Swath 5km	MOD10L2C	0.17				0:46	1:32 (8)	3:14
L2 Sea Ice Extent							1:30	

## Aqua

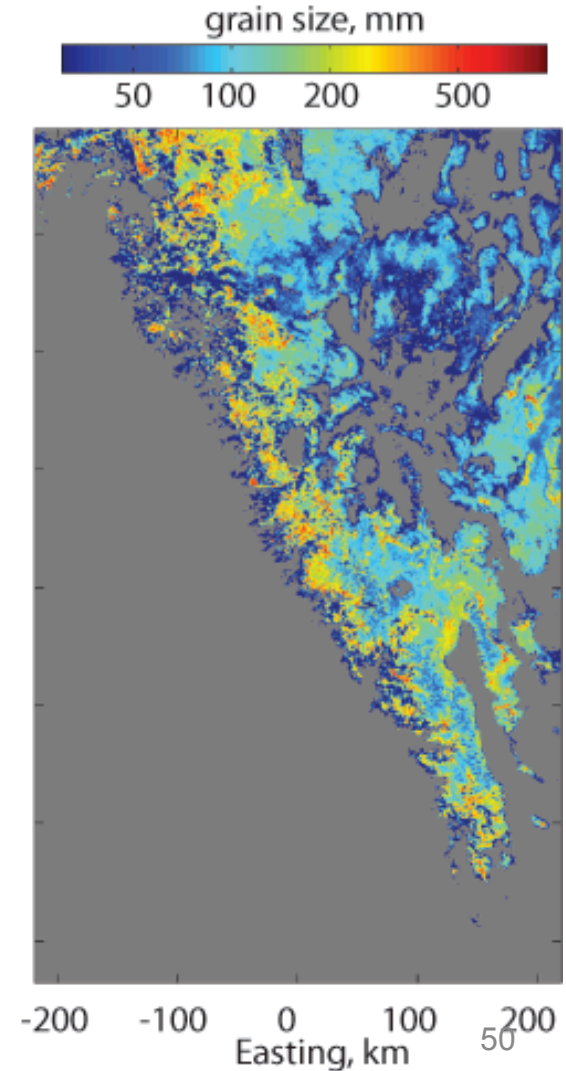
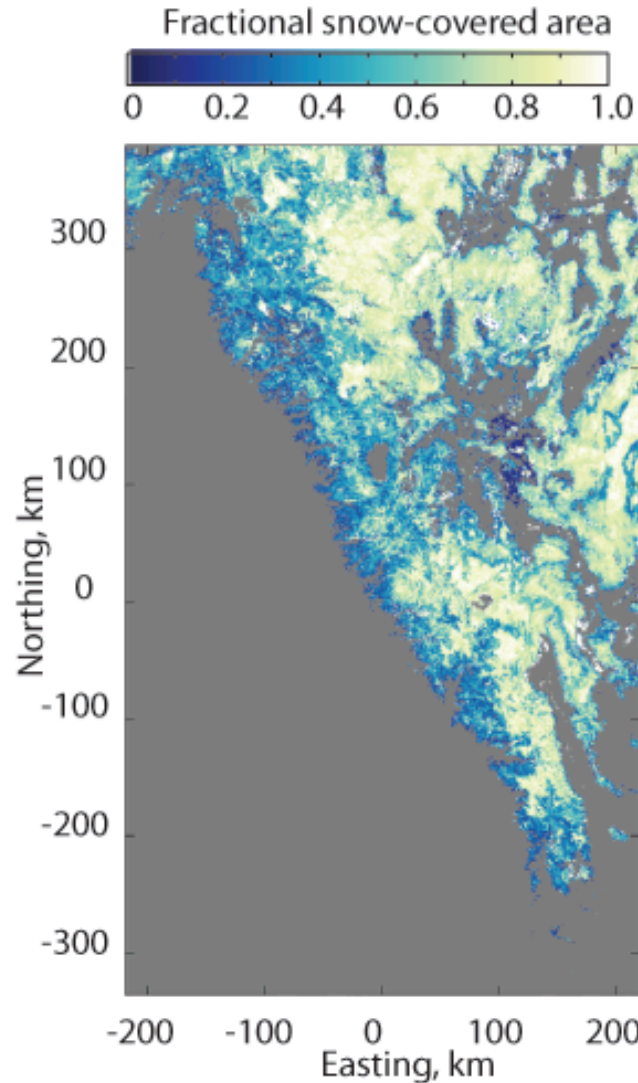
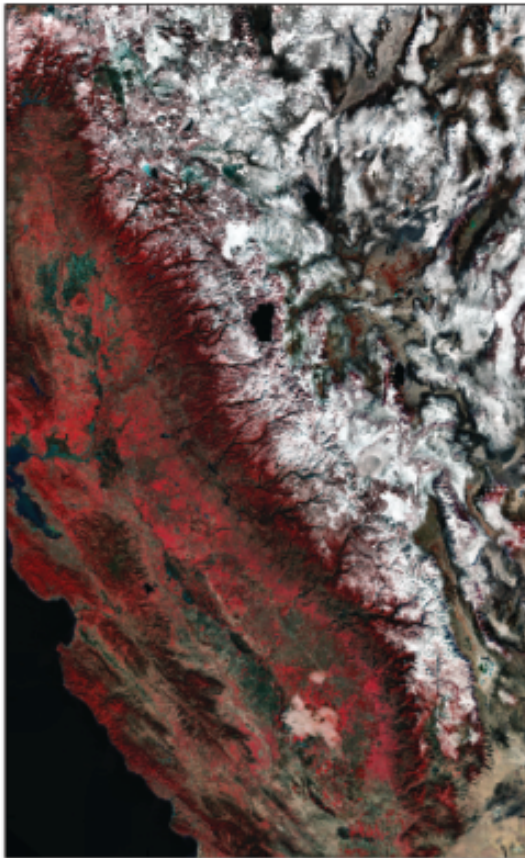
			Browse					
L2 Snow Cover, 5-Min Swath 500m	MYD10_L2	0.26	L2 Snow Cover Browse	N/A	07	1:00	1:47 (25)	3:30
L2 Coarse Snow Cover, 5-Min Swath 5km	MYD10L2C	0.17				1:00	1:47 (25)	3:30



# MODSCAG Snow Products

From: Thomas H. Painter and Chris Mattmann (NASA JPL)

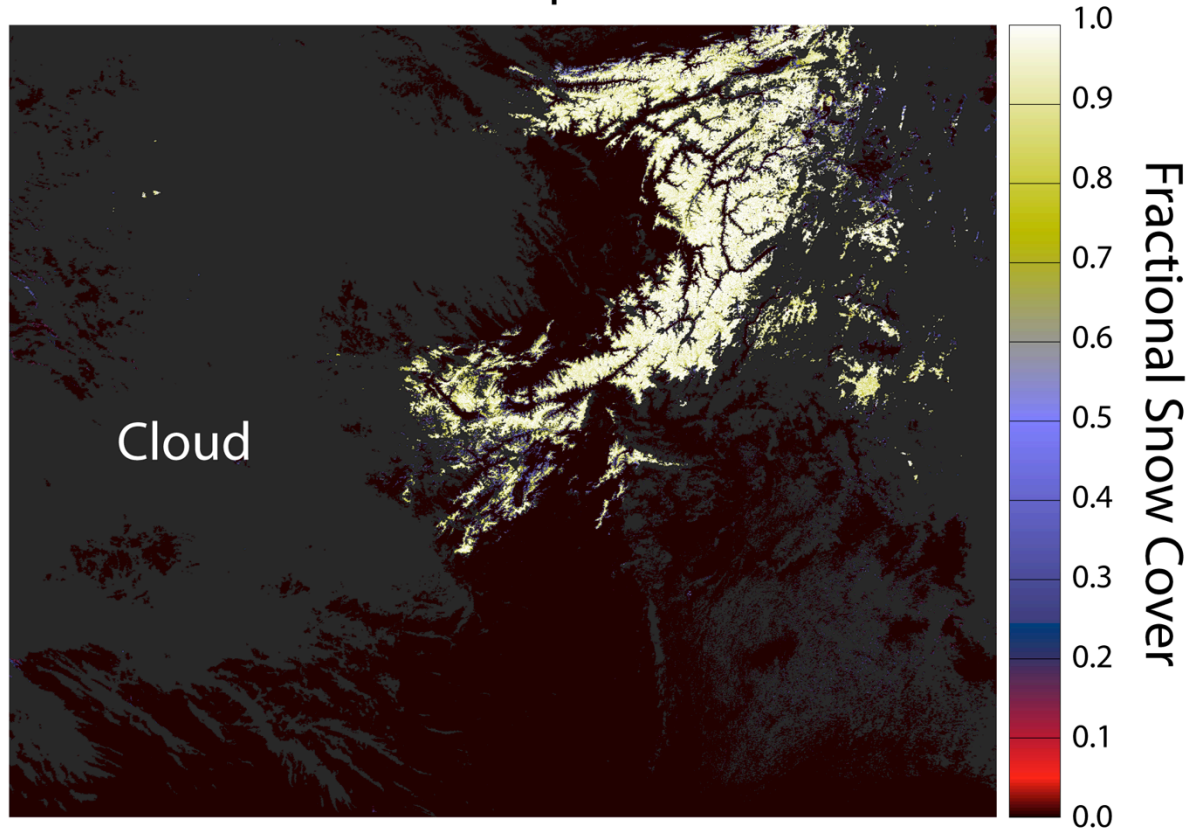
Bands 2,4,3 (RGB)



# MODSCAG

<http://snow.jpl.nasa.gov/portal/browse/dataset/urn:snow:MODSCAG>


Hindu Kush April 9/2009



**Limitation of MODIS Data : No Snow Mapping Under Clouds**



<http://snow.jpl.nasa.gov/portal/browse/dataset/urn:snow:MODSCAG>

 **Jet Propulsion Laboratory**  
California Institute of Technology

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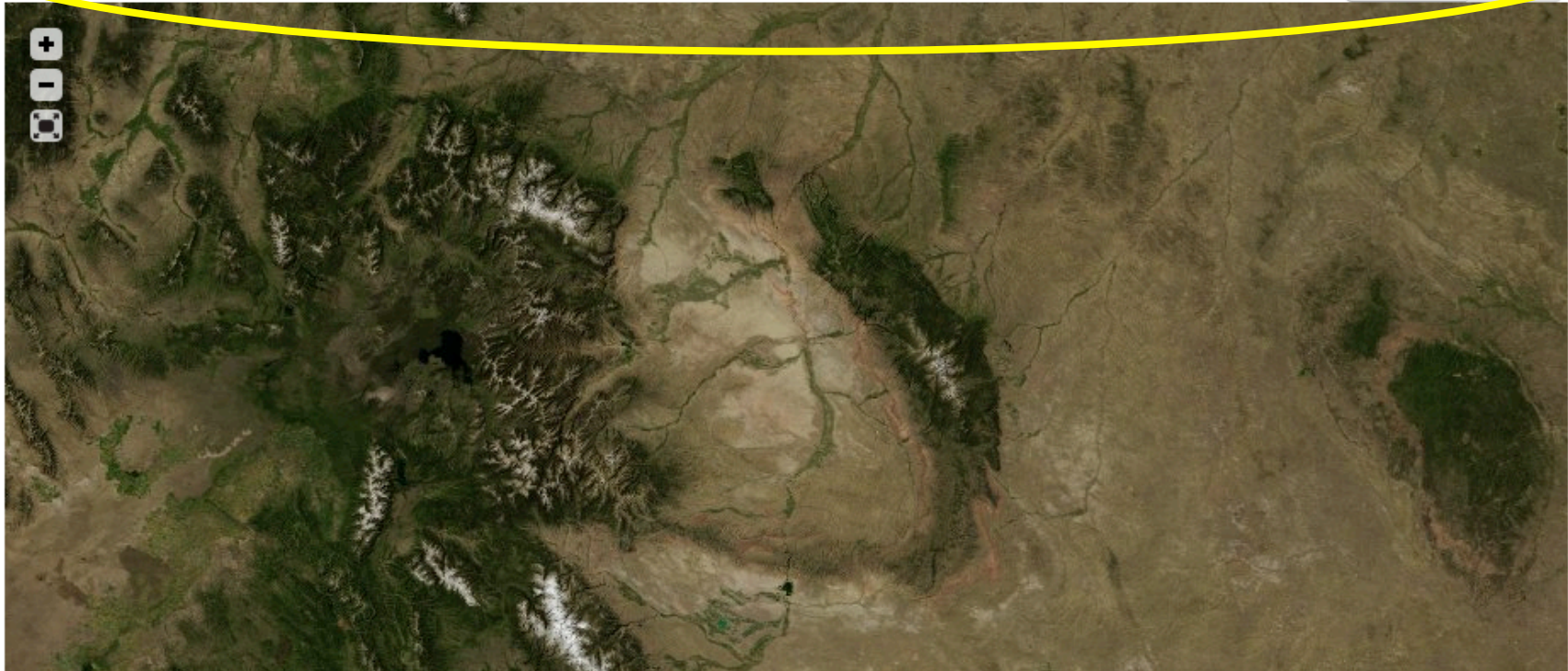
Snow Data System : Home → Data → Snow Map

Home **Data** Publications Media People Links

Date:

☒ Snow Cover ☐ Grain Size ☐ Dust Forcing ☒ Clouds ☐ RGB

Regions:



Map navigation controls: +, -, Full Screen, Refresh

## MODSACG Data Access and Mapping



# Water Resources



## Integration of Precision NASA Snow Products with the Operations of the Colorado Basin River Forecast Center (CBRFC) to Improve Decision Making Under Drought Conditions

Principle Investigator: Thomas Painter, Jet Propulsion Laboratory

### Abstract

The Colorado Basin River Forecast Center (CBRFC) is responsible for the entire Colorado Basin (CRB) and the eastern Great Basin (GB). From a water management perspective, the commitment of water to various users most often occurs in the spring, and is almost entirely based on estimates of the western USA snowpack. Improving seasonal drought predictions requires use of models that provide physically realistic simulations of fundamental hydrologic processes. Among these, for the western USA, representation of snow is perhaps most critical.

As drought frequency increases in the CRB and GB, it is critical that the CBRFC and the dependent water managers have more comprehensive real-time knowledge of the snow cover and its properties for more precise runoff forecasting and stakeholder decision support. The primary objective of this proposal is to integrate real-time high precision MODIS Snow Covered Area and Grain size (MODSCAG) fractional snow covered area (SCA) into CBRFC modeling and analysis systems and into stakeholder oriented data products, drastically reducing SCA uncertainties that have hampered forecasting operations for decades. A secondary objective is to ingest and study MODIS Dust Radiative Forcing in Snow (MODDRFS) radiative forcing imagery, to better understand its value as an input to modeling and forecasting approaches.

This collaboration directly addresses drought prediction, assessment, adaptation, and mitigation in support of energy security/efficiency; natural resource conservation; and household, municipal, industrial, and in-stream demands for water. It will also improve access and availability of actionable water monitoring, hence drought information. The Snow Cover and Dust Forcing products will be generated and distributed in near real-time by the JPL Snow Server for access by CBRFC. CBRFC will offer a direct connection to stakeholders (End Users) and together with other linked NWS operational centers provides an institutional home to maintain the advances of this effort beyond the project's end.

[top](#)

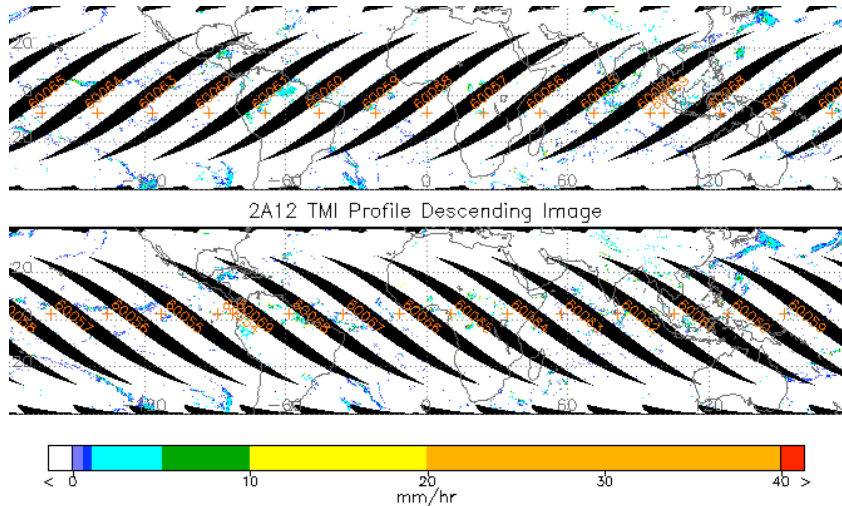
MODSCAG, Snow and Dust Radiative Forcing Information, along with CBRFC Modeling Analysis is used in **Decision Making for River Basin management**

Next:

Hands-on Activity to  
Access, Visualize, Download Monthly TMPA  
Data using Giovanni-4

# TRMM TMI and PR Measurements

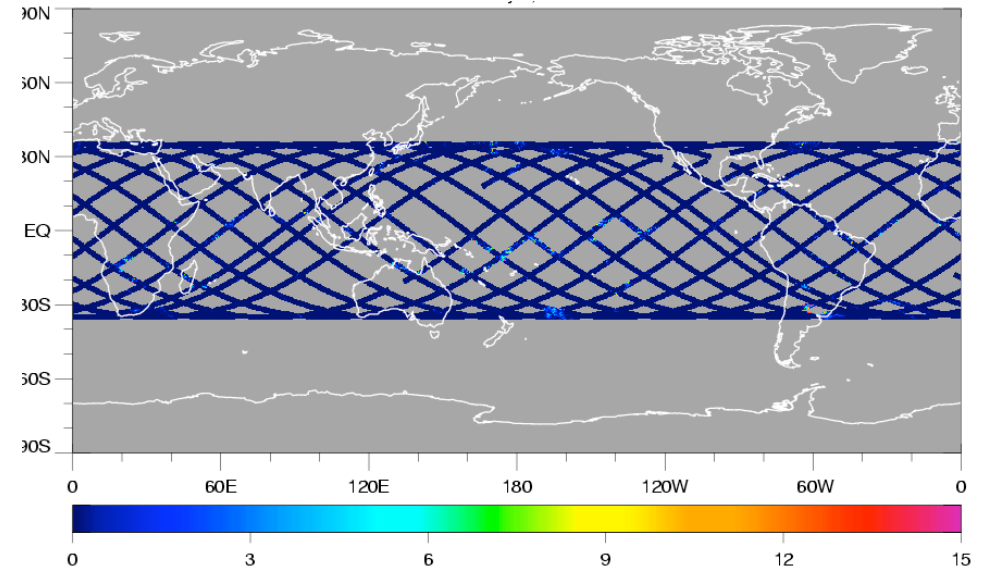
## TMI



2008/05/31 image contains 16 orbits, orbit numbers from 60054 to 60069

Frequencies: 10.7, 19.4, 21.3, 37, 85.5 GHz  
Swath: 760 km (870\* km)  
Resolution: 5 to 45 km (channel-dependent)

## PR<sup>+</sup>



Frequencies: 13.6 GHz  
Swath: 220 km (247\* km)  
Resolution: 5 km

\* After the orbit was raised in August 2001    +Stopped after October 7, 2014

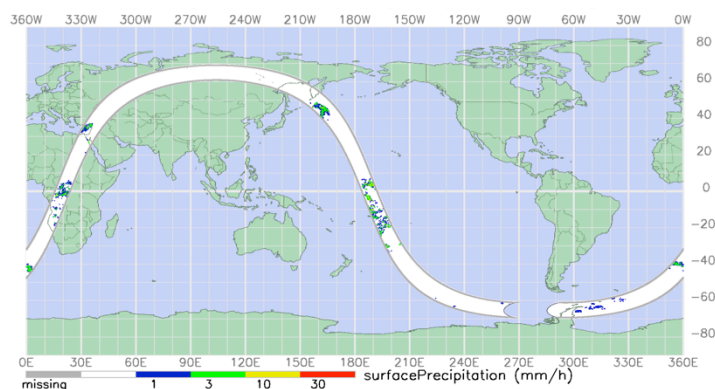
**Strength:** High pixel resolution, Accurate measurements

**Limitation:** No global, diurnal coverage on daily basis

# GPM GMI and DPR Measurements

<http://pmm.nasa.gov/GPM>

## GMI



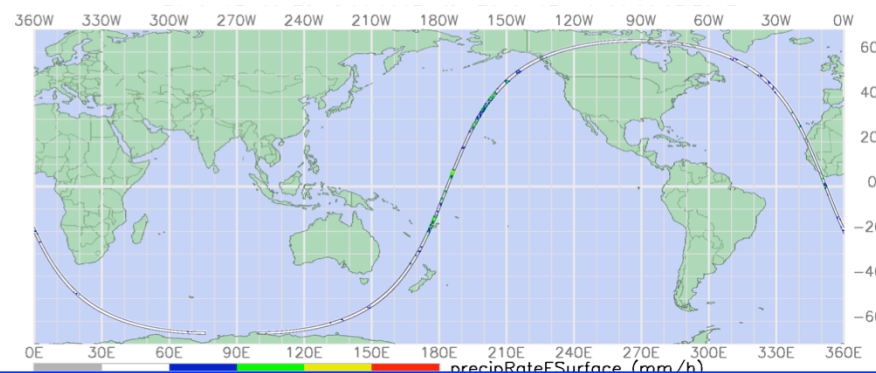
GMI Frequencies:  
10.6, 18.7, 23.8, 36.5, 89, 166 & 183 GHz

Swath width 885 km

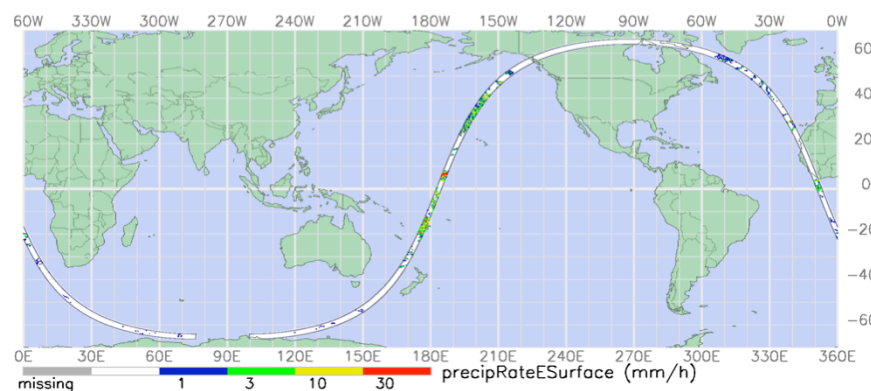
Resolution: 19.4km x 32.2km (10 GHz)  
to 4.4km x 7.3km (183 GHz)

Higher spatial resolutions than TMI  
High frequencies help measure snow

## DPR



Ka 35.5 GHz, Swath Width 120 km, Resolution 5.2 km



Ku 13.6 GHz, Swath Width 245 km, Resolution 5.2 km